The opinion in support of the decision being entered today was not written for publication and is not binding precedent of the Board.

Paper No. 19

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE BOARD OF PATENT APPEALS
AND INTERFERENCES

Ex parte MAMORU SHOJI,
ATSUSHI NAKAMURA, TAKASHI ISHIDA
and
SHUNJI OHARA

Appeal No. 2002-1674
Application 09/089,901

ON BRIEF

Before KRASS, FLEMING, and RUGGIERO, *Administrative Patent Judges*.

RUGGIERO, *Administrative Patent Judge*.

DECISION ON APPEAL

This is a decision on the appeal from the final rejection of claims 1-20, which are all of the claims pending in the present application.

The claimed invention relates to an apparatus and method for recording on or reproducing information from an optical disk in which groove-shaped groove tracks and land tracks present between the groove tracks are alternately connected to each other in a spiral shape. More particularly, a signal is recorded in both at least one continuous groove track and at least one continuous land track and, thereafter, the signal is reproduced from both the groove track and land track. Control parameters are determined based on a detected quality of the recorded and reproduced signal. Appellants assert (specification, pages 29 and 30) a savings in time and number of disk rotations over the conventional approach in which optimal control settings are obtained separately for the land and groove tracks.

Claim 1 is illustrative of the invention and reads as follows:

1. An optional disk apparatus performing either one of recording and reproduction of an optical disk in which groove-shaped groove tracks and land tracks present between the groove tracks are alternately connected to each other in a spiral shape, comprising:

a recording and reproduction unit for recording a signal in both at least one continuous groove track and at least one continuous land track, and after recording the signal in both the

groove track and the land track, then reproducing the signal from both the groove track and the land track;

a detector for detecting a quality of the signal thus recorded and reproduced by the recording and reproduction unit;

a control parameter setting unit for setting a control parameter related to at least one of the recording and the reproduction of the optical disk; and

a controller for changing the control parameter set by the control parameter[1] setting unit, repeating the recording and reproduction performed by the recording and reproduction unit and detection performed by the detector every time the control parameter is changed, and determining the control parameter based on the quality of the signal detected by the detector.

The Examiner relies on the following prior art references:[2]

Johann et al. (Johann)	5,341,360	Aug. 23, 1994
Moriya et al. (Moriya)	5,508,995	Apr. 16, 1996
Pietrzykoski et al. (Pietrzykoski)	5,812,506	Sep. 22, 1998
	(effectively filed	Oct. 02, 1996)
Nakane et al (Nakane '932)	5,936,932	Aug. 10, 1999
	(filed	Mar. 25, 1997)
Nakane et al. (Nakane '285)	5,946,285	Aug. 31, 1999
	(filed	Feb. 28, 1997)
Nakane et al. (Nakane '699))	6,091,699	Jul. 18, 2000
	(filed	Apr. 10, 1997)

[1] The language "set by the control parameter" is inadvertently duplicated at line 2 of claim 1 appearing in the amendment filed August 7, 2000, Paper No. 8.

[2] In addition, the Examiner relies on Appellants' admissions as to the prior art at pages 29 and 30 of Appellants' specification.

Ohara et al. (Ohara)[3] JP 4-141827 May 15, 1992
(Published Japanese Patent Application)

Claims 1-20, all of the appealed claims, stand finally rejected under 35 U.S.C. § 103(a).[4] As evidence of obviousness, the Examiner offers JP 4-141827 in view of Moriya with respect to claims 1, 2, 7, 9, 11, 12, 17 and 19. The Examiner adds the admitted prior art to the basic combination of JP 4-141827 and Moriya with respect to claims 3, 6, 13, and 16, and adds Pietrzykoski to the basic combination with respect to claims 8, 10, 18, and 20. The Johann reference is further added to the combination of JP 4-141827, Moriya, and the admitted prior art with respect to claims 4, 5, 14, and 15. In a separate rejection under 35 U.S.C. § 103(a), any one of Nakane '285, Nakane '699, or Nakane '932, is added to each of the stated rejections listed above.

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[3] Since both Appellants and the Examiner refer to the Ohara reference by document number (JP 4-141827), we will do so also to maintain consistency. A copy of an English translation of this reference provided by the U.S. Patent and Trademark Office, April 2000, is enclosed with this decision.

[4] As indicated at page 2 of the Answer, the Examiner has withdrawn the 35 U.S.C. § 112, first paragraph, rejection of claims 1-20.

Rather than reiterate the arguments of Appellants and the Examiner, reference is made to the Briefs[5] and Answer for the respective details.

OPINION

We have carefully considered the subject matter on appeal, the rejections advanced by the Examiner, the arguments in support of the rejections, and the evidence of obviousness relied upon by the Examiner as support for the rejections. We have, likewise, reviewed and taken into consideration, in reaching our decision, Appellants' arguments set forth in the Briefs along with the Examiner's rationale in support of the rejections and arguments in rebuttal set forth in the Examiner's Answer.

It is our view, after consideration of the record before us, that the evidence relied upon and the level of skill in the particular art would have suggested to one of ordinary skill

[5] The Appeal Brief was filed August 2, 2001 (Paper No. 14). In response to the Examiner's Answer dated September 7, 2001 (Paper No. 15), a Reply Brief was filed January 2, 2002 (Paper No. 16), which was acknowledged and entered by the Examiner as indicated in the communication dated April 23, 2002 (Paper No. 18).

in the art the obviousness of the invention as set forth in claims 1-20. Accordingly, we affirm.

Appellants' arguments in response to the Examiner's rejection of the appealed claims are organized according to a suggested grouping of claims indicated at page 5 of the Brief. We will consider the appealed claims separately only to the extent separate arguments for patentability are presented. Any dependent claim not separately argued will stand or fall with its base claim. Note In re King, 801 F.2d 1324, 1325, 231 USPQ 136, 137 (Fed. Cir. 1986); In re Sernaker, 702 F.2d 989, 991, 217 USPQ 1, 3 (Fed. Cir. 1983). Only those arguments actually made by Appellants have been considered in this decision. Arguments which Appellants could have made but chose not to make in the Briefs have not been considered [see 37 CFR § § 1.192(a)].

As a general proposition in an appeal involving a rejection under 35 U.S.C. § 103, an Examiner is under a burden to make out a prima facie case of obviousness. If that burden is met, the burden of going forward then shifts to Appellants to overcome the prima facie case with argument and/or evidence. Obviousness is then determined on the basis of the evidence as a whole and the

relative persuasiveness of the arguments. See In re Oetiker, 977 F.2d 1443, 1445, 24 USPQ2d 1443, 1444 (Fed. Cir. 1992); In re Hedges, 783 F.2d 1038, 1039, 228 USPQ 685, 686 (Fed. Cir. 1986); In re Piasecki, 745 F.2d 1468, 1472, 223 USPQ 785, 788 (Fed. Cir. 1984); and In re Rinehart, 531 F.2d 1048, 1052, 189 USPQ 143, 147 (CCPA 1976).

With respect to independent claims 1 and 11, Appellants' arguments in response to the Examiner's obviousness rejection based on the combination of JP 4-141827 and Moriya initially assert a failure by the Examiner to set forth a prima facie case of obviousness since all of the claimed limitations are not taught or suggested by the applied prior art references. After careful review of the applied JP 4-141827 and Moriya references in light of the arguments of record, we find Appellants' assertions to be unpersuasive. In our view, Appellants' arguments unpersuasively focus on the individual differences between the limitations of claims 1 and 11 and each of the applied references. It is apparent, however, from the Examiner's line of reasoning in the Answer, that the basis for the obviousness rejection is the combination of JP 4-141827 and

Moriya. One cannot show nonobviousness by attacking references individually where the rejections are based on combinations of references. In re Keller, 642 F.2d 413, 425, 208 USPQ 871, 881 (CCPA 1981); In re Merck & Co., Inc., 800 F.2d 1091, 1097, 231 USPQ 375, 380 (Fed. Cir. 1986).

In other words, while Appellants contend (Brief, pages 6-10) that the JP 4-141827 reference, in contrast to the claimed invention, has no disclosure of continuous recording on land and groove tracks thereby requiring separate evaluations of such groove and land tracks, the feature of continuous recording and/or reproducing on alternate land and groove tracks is clearly taught by Moriya. Similarly, while Appellants contend that Moriya fails to teach the setting and evaluation of control parameters after a recording and reproducing cycle, this teaching is specifically provided by JP 4-141827.

We further find to be unpersuasive Appellants' arguments in the Briefs which assert that:

> [w]hile the elements of the claimed invention, e.g., recording and reproducing from each of the lands and grooves, may be present in the prior art, none of the references contains any suggestion which would motivate a person of skill in the art to select and combine the presently claimed features as recited in Appellants' claims. (Brief, pages 17 and 18).

Our review of the applied prior art references in addition to Appellants' acknowledged prior art reveals that, in our view, even assuming, arguendo, that there is no explicit teaching in the references themselves suggesting their combination, the nature of the existing problems as described in the references clearly suggests their combination. As the Federal Circuit recently stated," ... this court has consistently stated that a court or examiner may find a motivation to combine prior art references in the nature of the problem to be solved." See Ruiz v. A.B. Chance, 357 F.3d 1270, 1276, 69 USPQ2d 1686, 1690 (Fed. Cir. 2004).

As discussed by Appellants at pages 29 and 30 of their specification, and as argued at pages 3, 4, and 6 of the Brief, the acknowledged prior art and JP 4-141827 disclose the recording and subsequent reproducing of information on land tracks and groove tracks separately. As evident from the described operation of the acknowledged prior art, in order to gather necessary control setting information from the land and groove tracks, it is necessary to jump from an outer land or groove track to an inner land or groove track.

Similarly, the Moriya reference also recognizes the problems of recording and/or reproducing information on separate land and groove tracks including the need to jump, for example, from an outer groove track to an inner land track in order to continuously record or reproduce information (Moriya, column 12, lines 35-55). To address this "track jumping" problem, Moriya teaches the use of a single spiral format (Example 2, beginning at column 12, line 56) with alternately connected land and groove tracks as presently claimed. In our view, Appellants' arguments notwithstanding, the nature of the problem to be solved coupled with Moriya's suggested alternate land/groove track solution provides clear motivation to the skilled artisan to modify the separate land and groove track format of the acknowledged prior art and JP 4-141827. Moriya also provides for the identification of land and groove tracks in the form of a track address (Moriya, column 13, lines 40-50).

We also make the observation that, in our view, the language of claims 1 and 11 which sets forth the recording and reproducing operation does not distinguish over the operation of the conventional system acknowledged as prior art by Appellants.. For

example, the repeated record and reproduce operations in the prior art, as would be necessary to achieve optimum control settings (e.g., as discussed in JP 4-141827) would result in recording on a continuous land track and on a continuous groove track, i.e., a recording on both land and groove tracks, followed eventually by reproduction from both the land and groove tracks as claimed. While such an operation may not be the same as that specifically disclosed by Appellants, it is the claimed invention which is at issue in this appeal. To whatever extent Appellants are alleging a reduction of disk revolutions as a distinguishing factor in the present appealed claims, no such language appears in the claims.

For the above reasons, since it is our opinion that the Examiner's prima facie case of obviousness has not been overcome by any convincing arguments from Appellants, the Examiner's 35 U.S.C. § 103(a) rejection of independent claims 1 and 11 is sustained.

Turning to a consideration of the Examiner's 35 U.S.C. § 103(a) rejection of dependent claims 2 and 12, grouped and argued together by Appellants, we sustain this rejection as well.

It is apparent to us, as implied by the Examiner, that the land and groove tracks in the applied prior art have control parameters in common, e.g., the focus position in Appellants' acknowledged prior art and the power discussed at column 12, line 61 of Moriya.

We also sustain the Examiner's obviousness rejection of dependent claims 7, 9, 17, and 19 grouped together by Appellants. We find no compelling arguments from Appellants that convince us of any error in the Examiner's assertion that power can be interpreted as intensity, as discussed at page 5 of the English translation of JP 4-141827, nor in the Examiner's position with respect to the claimed groove track and land track sectors (Answer, pages 9 and 10).

As to the Examiner's 35 U.S.C. § 103(a) rejection of dependent claims 3-6, 8, 10, 13-16 and 20 grouped together by Appellants, in which the Johann and Pietrzykoski references are applied to address the various claimed features, we sustain this rejection as well. Appellants' arguments (Brief, pages 13-15) rely on assertions made previously with respect to independent

claims 1 and 11, assertions which we found to be unpersuasive as discussed supra.

Lastly, we also sustain the Examiner's obviousness rejection of all the appealed claims in which the Nakane references are added to each of the rejections previously discussed. Although the Examiner has added the Nakane references to supply a teaching of a single spiral-land/groove (SS-L/G) recording format, we consider such teachings to be cumulative to those of Moriya for all of the reasons discussed above. Accordingly, it is our opinion that the Nakane references are not necessary for a proper obviousness rejection of the appealed claims, and the Examiner's various obviousness rejections are sustained based on the applied prior art without the Nakane references.

In summary, we have sustained the Examiner's 35 U.S.C. § 103(a) rejection of all of the claims on appeal. Therefore, the decision of the Examiner rejecting claims 1-20 is affirmed.

No time period for taking any subsequent action in connection with this appeal may be extended under 37 CFR § 1.136(a).

AFFIRMED

ERROL A. KRASS Administrative Patent Judge	)	
MICHAEL R. FLEMING Administrative Patent Judge	)	BOARD OF PATENT APPEALS AND INTERFERENCES
JOSEPH F. RUGGIERO Administrative Patent Judge	)	

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PN=04141827

OPTICAL DISK DEVICE THAT CAN SET OPTIMUM POWER
[Saitei pawaa settei kano na hikari disuku sochi]

Shunji Ohara et al.

UNITED STATES PATENT AND TRADEMARK OFFICE
Washington, D.C. April 2000

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APPLICANT	(71):	MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD.
TITLE	(54):	OPTICAL DISK DEVICE THAT CAN SET OPTIMUM POWER
FOREIGN TITLE	[54A]:	SAITEI PAWAA SETTEI KANO NA HIKARI DISUKU SOCHI

Specification /1

1. Title of the Invention

Optical disk device that can set optimum power

2. Claims

(1) Optical disk device that can set optimum power that in a device that records signals by irradiating laser light on a recording medium, it has

a means that first records a signal on an evaluation track while gradually varying the recording power of the abovementioned laser light, a reproduction signal quality discriminating means that discriminates whether the abovementioned recorded signal is good or bad, a means that sets the lowest minimum power within the range of recording power in which the abovementioned recording signal can be discriminated as good by the abovementioned reproduction signal quality discriminating means, and a means that finds the optimum power by adding a set power to the abovementioned minimum power.

(2) Optical disk device that can set optimum power described in Claim 1 that in a device that records signals by irradiating laser light on a recording medium at the two levels of bias power and peak power, it has

a means that first fixes the abovementioned bias power and furthermore records a signal while gradually varying the abovementioned peak power, a reproduction signal quality discriminating means that

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*Numbers in the margin indicate pagination in the foreign text.

discriminates whether or not the abovementioned recorded signal is usable, a means that sets the lowest peak power within the range of recording power in which the abovementioned recording signal can be discriminated as usable by the abovementioned reproduction signal quality discriminating means as the minimum peak power, a means that next fixes the abovementioned peak power and furthermore records a signal while gradually varying the abovementioned bias power, the abovementioned reproduction signal quality discriminating means that discriminates whether or not the abovementioned recorded signal is usable, a means that sets the lowest bias power within the range of recording power in which the abovementioned recording signal can be discriminated as usable by the abovementioned reproduction signal quality discriminating means as the minimum bias power, and a means that finds the optimum power by adding a set power to both of the abovementioned minimum powers.

(3) Optical disk device that can set optimum power described in Claim 1 or 2 that has a bit error discriminating means as the reproduction signal quality discriminating means.

(4) Optical disk device that can set optimum power described in Claim 1, 2, or 3 that as the reproduction signal quality discriminating means, has a comparison voltage generating means that has a reference voltage and a comparison voltage(s) that is higher and/or lower than the abovementioned reference voltage, a comparator means that compares the reproduction signal to the abovementioned comparison voltage and makes it binary, and a means that discriminates bit error in the abovementioned binary signal.

(5) Optical disk device that can set optimum power described in Claim 1, 2, or 3 that as the reproduction signal quality discriminating means, has a comparator means for making the reproduction signal binary, a phased lock loop (PLL) means that has a reference frequency and a higher frequency than the abovementioned reference frequency and/or a lower frequency than the abovementioned reference frequency, a means that extracts the data of the abovementioned binary signal based on the higher frequency and/or lower frequency than the abovementioned reference, and a means that discriminates bit error in the abovementioned data.

(6) Optical disk device that can set optimum power described in Claim 1 or 2 that uses a reproduction signal amplitude discriminating means as the reproduction signal quality discriminating means, and has a means that sets the minimum permissible power for reproduction signal amplitude obtained by the abovementioned reproduction signal amplitude discriminating means as the minimum power, and a means that finds the optimum power by adding a set power to the abovementioned minimum power.

(7) Optical disk device that can set optimum power that in a method that records and/or erases signals by irradiating laser light on a recording medium,

the optimum power for the abovementioned recording and/or erasing is set when power is turned on, or when the recording medium is replaced, or when the user finds that recorded data is bad, or after a set time has elapsed since optimum power was last corrected, or after the temperature has risen to a set level or greater, or after the device has been subjected to vibration or shock of a set level or greater.

3. Detailed Explanation of the Invention

(Industrial Field of Application)

This invention pertains to a device that irradiates minutely constricted laser light on a recording medium and records information optically.

(Prior Art)

Optical disk devices are known as devices that irradiate laser light on a disk-shaped recording medium and can record digital data or image signals. In the optical disk devices described above, the peak power irradiated on the disk is greatly affected by the quality of the recorded signal, and it is important to have a method for recording on the disk at optimum peak power. A prior art example of the abovementioned method is described in Japan Koho Patent No. 63-25408. As described in the Specifications, the method of this prior art example is a signal recording method in which, in a method that records information signals by irradiating recording light on a recording medium, a signal first is recorded while varying the intensity (peak power) of the recording light, this recorded signal is reproduced to set the optimum level of the abovementioned recording light intensity that produces the best reproduction signal, then the signal is recorded while controlling the abovementioned recording light intensity to this optimum level. Because in general optical disk media, the reproduction signal is best when it oscillates at the greatest amplitude, best reproduction signal status is defined as great reproduction signal amplitude. Therefore, even in the working examples of the abovementioned prior art example, the optimum light intensity (optimum peak power) is set by detecting

where the amplitude (P-P value) of the reproduction signal is greatest.
(Problems that the Invention is to Solve)

However, the prior art method has the problem that because it takes the peak power that produces the best reproduction signal status as the optimum peak power, the abovementioned optimum peak power is not the optimum peak power for the optical disk device.

Figure 8(a) shows peak power characteristics of a general optical disk, and Figure 8(b) shows the status of recording marks on the recording medium obtained at each peak power. In Figure 8(a), the horizontal axis shows peak power, and the vertical axis shows amplitude or S/N. In Figure 8(b), (31), (32), and (33) show recording marks at each peak power, and the arrow shows the track direction. At peak power from 0 to P1, power is still insufficient, adequate recording marks are not formed, and reproduction signal amplitude is inadequate. From P2, adequate recording marks as a reproduction signal start to be formed. As peak power increases from P1 to P2, recording marks also become larger and the reproduction signal increases. However, at greater than P2, recording marks have greater than 50% duty and the reproduction signal conversely begins to be reduced due to insufficient resolution. Furthermore, when peak power increases and becomes greater than P3, the recording medium now starts to break down and reproduction amplitude falls rapidly. Therefore, P2 is given as the peak power that produces the best reproduction signal (great reproduction signal amplitude in the working examples of the prior art example, or best S/N quality of the reproduction signal). The peak power characteristics described above differ depending on the type of recording medium as shown by (34), (35),

and (36) in Figure 9, and there are recording media such as recording medium (34) in which the abovementioned peak power level P2 that produces the maximum (best) reproduction signal is close to P1, recording medium (35) in which this conversely is close to P3, and recording medium (36) in which this is in the middle. The two axes in Figure 9 are the same as the two axes in Figure 8(a). In addition, as "optimum power of the optical disk device," because peak power on the disk is subject to substantial fluctuation when any sort of error in actual data recording status occurs (such as servo error due to vibration or shock, peak power discrepancy due to temperature change, or adhesion of dirt to the disk or lens), peak power P4 that is slightly higher than the center of the power range that does not impede recording and reproduction (for example, in the peak power characteristics in Figure 9, the range from Pa to Pc) is taken as the optimum peak power for the optical disk device. The reason for selecting a slightly higher power is because peak power often is substantially reduced when the abovementioned errors occur. X in Figure 9 is called margin power, and the abovementioned margin power is the permissible amount of the abovementioned power reduction before an error occurs.

As described above, the peak power that produces the best reproduction signal status for the optical disk (recording medium) (in Figure 9, P34, P35, and P36) is not always optimum peak power P4 for the optical disk device, and it is difficult to find the optimum peak power for the optical disk device by the prior art example that sets peak power by finding the best reproduction signal status.

Furthermore, the method of the prior art example cannot be applied

to an overwritable optical disk device. Figure 10 is a diagram that shows the irradiation method used to overwrite a phase-change material.

In Figure 10, (a) [sic] shows the optical modulation waveform, (b) [sic] shows the recording track before overwriting, (c) [sic] shows the recording track after overwriting, (40) [sic] indicates bias power, (41) [sic] indicates peak power, (42) [sic] indicates crystal state, and (43) [sic] indicates amorphous state. "Phase-change material" is a material in which signals can be overwritten by using the difference in optical reflection between amorphous state and crystal state. Here, "overwriting" means that a new signal can be recorded over signals recorded in the past without erasing these. As shown in Figure 10, both amorphous and crystal states are obtained by optical modulation between two levels of laser power, peak power and bias power. That is, regardless of which state the recording track is in before overwriting, places irradiated at peak power can be made amorphous state and places irradiated at bias power can be made crystal state, and a new signal can be overwritten in this way.

Even in an overwritable device such as described above, the optimum bias power and peak power must be set. However, the two levels of power required for overwriting cannot be set in the prior art example.

The purpose of this invention is to offer a device that solves the problems described above.

(Means of Solving the Problems)

To solve the problems described above, this invention has a start circuit that starts the optimum power setting operation, a means that after being commanded by the abovementioned start circuit, first fixes

the abovementioned bias power and furthermore records a signal while gradually varying the abovementioned peak power, a reproduction signal quality discriminating means that discriminates whether or not the abovementioned recorded signal is usable, a means that sets the lowest peak power within the range of recording power in which the abovementioned recording signal can be discriminated as usable by the abovementioned reproduction signal quality discriminating means as the minimum power, a means that next fixes the abovementioned peak power and furthermore records a signal while gradually varying the abovementioned bias power, the abovementioned reproduction signal quality discriminating means that discriminates whether or not the above-mentioned recorded signal is usable, a means that sets the lowest bias power within the range of recording power in which the abovementioned recording signal can be discriminated as usable by the abovementioned reproduction signal quality discriminating means as the minimum bias power, and a means that finds the optimum power by adding a set power to both of the abovementioned optimum powers, and user signals are overwritten at the abovementioned optimum power.

In addition, this invention uses a bit error discriminating means as the reproduction signal quality discriminating means, and sets the lowest of the two abovementioned powers within the power range that can allow bit error by the abovementioned bit error discriminating means as the two minimum powers, then finds the optimum power by adding a set power to both of the abovementioned minimum powers and overwrites user signals.

Furthermore, this invention performs the optimum power finding

operation described above when power is turned on, or when the recording medium is replaced, or when the user finds that recorded data is bad, or after a set time has elapsed since optimum power was last corrected, or after the temperature has risen to a set level or greater, or after the device is subjected to vibration or shock of a set level or greater.

(Operation)

By the constitution described above, this invention can find the optimum peak power for the optical disk device leaving a margin before peak power produces a bad reproduction signal regardless of the type of recording medium and even when peak power fluctuates during actual use. In addition, this invention can set the optimum peak power between the optical disk device and the optical disk (recording medium) at the point when the user actually seeks to use it.

(Working Examples)

Figure 1 is a block diagram that shows the first working example of an optical disk device of this invention for finding optimum peak power.

In Figure 1, (1) is an photodetector that detects a reproduction signal from an optical disk, (2) is an amplifier that amplifies the abovementioned reproduction signal, (3) is a demodulator that demodulates the data of the abovementioned reproduction signal and the address installed on the disk, (4) is an unrecorded parts detector that detects the presence or absence of a reproduction signal; (5) is a search circuit that searches for the intended track, (6) is a reproduction signal quality discriminating circuit, (7) is a modulator that modulates data from the drive control circuit described below, (8) is a recording gate generating circuit, (9) is a laser power control

circuit for recording and/or erasing signals, and (10) is a DA (digital-analog) convertor that sets the laser power level of the laser power control circuit by converting to analog the laser power level outputted by drive control circuit (11) comprised of a microcomputer. In addition, drive control circuit (11) is connected to demodulator (3), unrecorded parts detector (4), search circuit (5), reproduction signal quality discriminating circuit (6), modulator (7), and recording gate generating circuit (8), and gives commands to each of these circuits. For example, signal recording is performed by modulating data created by the drive control circuit to a recording signal by modulator (7), recording this by DA convertor (10), applying bias power, and commanding recording gate generating circuit (8) to open a recording gate. (19) is a start circuit that commands starting the operation to find optimum peak power using these circuits. The operation of the block diagram described above will be explained using the flowchart in Figure 2.

Upon command from start circuit (19), drive control circuit (11) starts the optimum power finding operation. First, drive control circuit (9) [sic; (11)] commands search circuit (5) to search for an evaluation track. An "evaluation track" is a track for evaluating recording status, and is, for example, a track not in a user region. The reproduction signal from the evaluation track is conducted from photodetector (1) through amplifier (2) to unrecorded parts detector (4) and demodulator (3). Unrecorded parts detector (4) detects whether or not there already is a recorded signal in the evaluation track, and if there is no signal, substitutes 0 in number repetitions register N within the drive control circuit. If there is a recorded signal already, the recorded signal is

demodulated by demodulator (3), the number of times (repetitions) this evaluation track has been used before now is read from the recording signal, and this number is substituted in number repetitions register N. If the abovementioned number of repetitions is Nmax-10 or greater, another evaluation track is searched by search circuit (5). Here, "Nmax" is the maximum number of times the abovementioned evaluation track can be recorded, and this is set as Nmax-10 from the consideration that the same evaluation track may be recorded repeatedly approximately 10 times thereafter until optimum peak power and optimum bias power are set. The number 10 is variable.

If the abovementioned newly searched other evaluation track is the final evaluation track, error 1 is established, the user is notified, and this optimum powering setting operation is ended. If the abovementioned other evaluation track is not the final evaluation track, whether or not there are data on the abovementioned evaluation track is rechecked and the number of repetitions is read. If the abovementioned number of repetitions is less than Nmax-10, reference peak power Pr set during design is set in peak power setting register P within the drive control circuit, and reference bias power Br set during design is set in bias power setting register B. Next, by substituting N + 1 in number repetitions register N, the abovementioned N data are recorded on the evaluation track at both of the abovementioned powers. The recording signal recorded at both of the abovementioned powers is evaluated in reproduction signal quality discriminating circuit (6), and if it is evaluated that it is no good (does not pass) as a reproduction signal, error 2 is notified to the user and this optimum powering setting

operation is ended. If it is evaluated as good (passes), optimum peak power is set first. The optimum peak power setting means is described below: Power is reduced exactly dX from the power set currently and set in peak power setting register P, and the abovementioned data are recorded by substituting data N + 1 in the number repetitions register. These data are evaluated by reproduction signal quality discriminating circuit (6), and if good, peak power is lowered by dX again. Peak power continues to be lowered until it is evaluated by reproduction signal quality discriminating circuit (6) as no good (does not pass). As soon as it is first evaluated by reproduction signal quality discriminating circuit (6) as no good (does not pass), the power obtained by adding dX to the value of peak power setting register P at this time becomes the minimum peak power at which data can be recorded accurately. When the abovementioned margin power X (see Figure 9) is weighted onto the abovementioned minimum peak power, this power Ps (Ps = P + dX + X) becomes the optimum peak power for the optical disk device.

In addition, optimum bias power is set by a similar means: Power is reduced exactly dY from the power set currently and set in bias power setting register B, and the abovementioned data are recorded by substituting data N + 1 in the number repetitions register. These data are evaluated by reproduction signal quality discriminating circuit (6), and if good, bias power is lowered by dY again. Bias power continues to be lowered until it is evaluated by reproduction signal quality discriminating circuit (6) as no good (does not pass). As soon as it is first evaluated by reproduction signal quality discriminating circuit (6) as no good (does not pass), the power obtained by adding dY to the

value of bias power setting register B at this time becomes the minimum bias power at which data can be recorded accurately. When margin power Y is weighted onto the abovementioned minimum bias power, this power Bs (Bs = B + dY + Y) becomes the optimum bias power for the optical disk device.

Next, details are described regarding the margin power X and Y calculated for the two minimum powers. This margin power is a power set such that even if peak power fluctuates substantially due to some sort of error in use status occurring after setting the abovementioned optimum power, this does not cause bias power to fluctuate; that is, the reproduction signal to become no good. The power selected for the abovementioned margin power X and Y is roughly one half or more of the maximum and minimum power range in which the reproduction signal is passed by reproduction signal quality discriminating circuit (6) (see Figure 9). This is made one half or more because it is considered that the main causes of power fluctuation are dirt and servo error, and both of these are more likely to reduce power than increase it. In addition, this margin power can be modified before the user actually records. For example, if the amount of margin power is modified when a certain time elapses after this optimum power setting operation before the user actually records or temperature change or a disturbance such as vibration or shock is detected, margin power reliability is increased.

To summarize this invention as described above, one of peak power or bias power is fixed and the other is reduced gradually (by dX or dY) from higher power, the lowest minimum power at which the recording signal is passed by reproduction signal quality discriminating circuit

(6) is found, and the power obtained by adding a margin power (X or Y) to the abovementioned minimum power becomes the optimum peak power or optimum bias power.

That is, the "optimum peak power" and "optimum bias power" of this invention are the optimum power for the optical disk device, and the "optimum power for the optical disk device" does not indicate the power that produces the optimum reproduction signal, but a peak power and bias power that have a margin power on the low power side and high power side even against some degree of error (substantial fluctuation in recording or erasing power) that causes reproduction to become no good.

A method for setting both optimum powers of peak power and bias power was described above, but for disks such as write-once type disks that record without using bias power, peak power only can be set by the method of this invention.

As conditions for start circuit (19) to start the operation of finding the abovementioned optimum power, the following are considered: When the power source of the optical disk device is turned on, and/or when the disk is replaced, and/or when the user finds that an error has occurred that makes reproduction of the recorded signal no good.

These try to correct optimum power between the optical disk device and the optical disk used now because of fluctuation (discrepancy) in performance between the optical disk device and the optical disk. In addition, besides as described above, cases may be considered such as having start circuit (19) house a timer and starting after a certain time has elapsed, or housing a temperature sensor and starting when the temperature has risen to a set level or greater, or housing a vibration

and shock sensor and starting when the device is subjected to vibration or shock of a set level or greater. These try to correct optimum power for performance during use because the performance of the optical disk device has changed due to change in the environment (such as temperature, vibration or shock, or dirt) during use of the optical disk device. All of these correct optimum power when the user is not writing data.

Figure 3 is a flowchart that illustrates another working example of this invention. The structure of the circuit block used is the same as in Figure 1, but the software within drive control circuit (11) is different. Because the operation from starting until an evaluation track is found in Figure 3 is the same as in Figure 2, this part is not explained again. However, the reason for setting the maximum number of repetitions as Nmax-2 is because the same evaluation track is used twice thereafter before finding the optimum power. This number is variable.

Generally, optical disks that can record data have a sector structure and the evaluation track is also comprised of several sectors. Therefore, data are recorded by varying each power for each sector. For example, peak power and bias power for each sector are set as follows: Peak power P0 for sector 0 is set as the abovementioned reference peak power Pr set during design, and at the same time, bias power B0 is set as reference bias power Br set during design. To set power P1 and B1 for sector 1, incremental power dX and dY are subtracted from the abovementioned Pr and Br. To set power P2 and B2 for sector 2, twice the abovementioned incremental power dX and twice dY are subtracted from the abovementioned Pr and Br. Similarly, to set power Pm and Pm for sector

m, each sector is recorded by subtracting m-times incremental power dX and m-times dY from the abovementioned Pr and Br.

The signals on all of the abovementioned recorded sectors are evaluated by reproduction signal quality discriminating circuit (6), and if the reproduction signal from sector k is good (passes), Pr - k•dX and Br - k•dY become the minimum peak power and minimum bias power, and the abovementioned margin power X and Y added to each of the abovementioned minimum powers, P = Pr - k•dX + X and B = Br + k•dY + Y, become the optimum peak power and optimum bias power.

Here, if signals recorded on all sectors while gradually varying power are all judged no good (do not pass) by reproduction signal quality discriminating circuit (6), this is notified to the user as error 2 and this optimum powering setting operation is ended.

As the method of this invention described above for finding the optimum power for the optical disk device, in both of the two methods described above, the optimum peak power and optimum bias power for the optical disk device are set after first finding the usable minimum peak power and/or minimum bias power by reproduction signal quality discriminating circuit (6).

Figure 4 is a diagram that illustrates operating principles when a bit error discriminating circuit is used as reproduction signal quality discriminating circuit (6), and shows bit error rate (hereinafter abbreviated BER) characteristics for peak power. The horizontal axis shows peak power and the vertical axis shows BER. As peak power is raised gradually from low power, BER improves (BER becomes lower). The permissible BER--for example, when BER is a multiple of four or less of

ten--is detected, and reproduction signal quality discriminating circuit (6) notifies the drive control circuit that the reproduction signal is good (passes) starting from this point. Therefore, the peak power at this time becomes the minimum power. When the reproduction signal is evaluated as good or bad by BER in this way, BER for peak power varies greatly near the minimum power, and the minimum peak power can be found easily. Conversely, because there is little change in BER when the minimum power is exceeded, it is difficult to find the peak power that produces the best reproduction signal.

When any sort of error described above occurs in actual use, it is considered that peak power substantially drops to the minimum power. Therefore, to increase signal reliability at the minimum power, BER at the minimum power is strictly measured as described below.

Figure 5 shows another working example of reproduction signal quality discriminating circuit (6) used in this invention. The reproduction signal of the evaluation track obtained from amplifier (2) is inputted to terminal I, and the evaluation result of reproduction signal quality discriminating circuit (6) is notified to the drive control circuit from terminal J. Normally, the analog signal of the abovementioned reproduction signal is compared to comparison voltage Vt obtained from comparison voltage generating circuit (12) (generally one half the voltage of the reproduction signal amplitude) by comparator circuit (13), made binary, and sent to bit error discriminating circuit (14). However, to increase signal reliability at the minimum power, in the process of finding the abovementioned minimum power, the abovementioned comparison voltage is switched between two voltages Vt +

dVt and Vt - dVt, and the minimum power at which bit error does not occur even when compared to the abovementioned two voltages is taken as the minimum power of recording and/or bias power. By using two voltages with some leeway as the comparison voltages as described above, reproduction signal amplitude unevenness due to insufficient peak power or bit error caused by erasure residue due to insufficient bias power can be found with greater strictness, and reliability of the recording signal at minimum power can be improved.

Figure 6 shows another working example for increasing signal reliability at the minimum power. Figure 6 shows another working example of reproduction signal quality discriminating circuit (6) used in this invention. Structural elements that are the same as Figure 5 are labeled by the same part numbers. From the signal made binary by the comparator, the reference clock is read by standard PLL (phased lock loop) circuit (15). Using the abovementioned reference clock, data are extracted by data extracting circuit (16), and sent to bit error discriminating circuit (14). Normally, data clock frequency fc is selected for the abovementioned reference clock. However, to increase signal reliability at the minimum power, in the process of finding the abovementioned minimum power, the abovementioned reference clock frequency is switched between two frequencies fc + dfc and fc - dfc, and the minimum power at which bit error does not occur even when extracted at the abovementioned two frequencies is taken as the minimum power of recording and/or bias power. By using two frequencies with some leeway as the reference clock as described above, bit error caused by deterioration in S/N due to insufficient peak power or bias power, or put another way, reproduction

signal jitter (oscillation of the reproduction signal on the time axis) can be found with greater strictness, and reliability of the recording signal at minimum power can be improved.

Figure 7 is a diagram that illustrates operating principles when a reproduction signal amplitude discriminating circuit is used as reproduction signal quality discriminating circuit (6), and shows reproduction signal characteristics for peak power. The horizontal axis shows peak power and the vertical axis shows reproduction signal amplitude. As peak power is raised gradually from low power, the reproduction signal amplitude increases. It is detected when this exceeds permissible amplitude Vb, and reproduction signal quality discriminating circuit (6) notifies the drive control circuit that the reproduction signal is good (passes) starting from this point. Therefore, the peak power at this time becomes the minimum power. Thus, reproduction signal amplitude varies greatly near the minimum power, and the minimum peak power can be found easily. Conversely, because there is little change in reproduction signal amplitude when the minimum power is exceeded, it is difficult to find the peak power that produces the greatest reproduction signal amplitude as in the prior art example.

(Effects of the Invention)

As has been explained above, because this invention is designed such that it finds the optimum power for the optical disk device after finding the minimum power of peak power and bias power, the optimum power can found easily and the optimum power can be set securely and readily. In addition, the optimum power found by this invention is the optimum power for the optical disk device. Therefore, even if errors

occur such as servo error or power fluctuation due to environmental change in use status, there is a margin power before the reproduction signal becomes no good and stability of the optical disk device is improved.

Furthermore, according to this invention, because whether the signal is good or bad is evaluated more strictly than normal for a recording reproduction signal at the minimum power, signal reliability at the minimum power is high. Furthermore, according to this invention, even when there is fluctuation (discrepancy) in performance between the optical disk device and the optical disk (recording medium), optimum power can be corrected between the optical disk device and the optical disk used henceforth, and even when the performance of the optical disk device changes due to change in the environment (such as temperature, vibration or shock, or dirt), optimum power can be corrected for the performance at that point. As a result, this invention has the effect that it can offer an optical disk device that is not affected by discrepancies in performance and environmental change and has high reliability.

4. Brief Explanation of the Figures

Figure 1 is a block diagram of the optical disk device that can set optimum power in the first working example of this invention. Figure 2 is a flowchart that shows one working example of the optimum power setting method of this invention. Figure 3 is a flowchart that shows another working example of the optimum power setting method of this invention. Figure 4 is a graph that illustrates the principles of one

working example of a reproduction signal quality discriminating circuit used in this invention. Figure 5 is a block diagram of one working example of a reproduction signal quality discriminating circuit used in this invention. Figure 6 is a block diagram of another working example of a reproduction signal quality discriminating circuit used in this invention. Figure 7 is a graph that illustrates the principles of another working example of a reproduction signal quality discriminating circuit used in this invention. Figure 8 and Figure 9 are graphs of peak power characteristics that illustrate problems in prior art examples. Figure 10 is a diagram that illustrates principles of recording on a phase-change type optical disk.

6 ... reproduction signal quality discriminating circuit, 9 ... laser power setting circuit, 11 ... drive control circuit, 12 ... reference voltage generating circuit, 13 ... comparator circuit, 14 ... bit error discriminating circuit, 15 ... PLL circuit, 16 ... data discriminating circuit, 19 ... start circuit, 40 ... bias power, 41 ... peak power

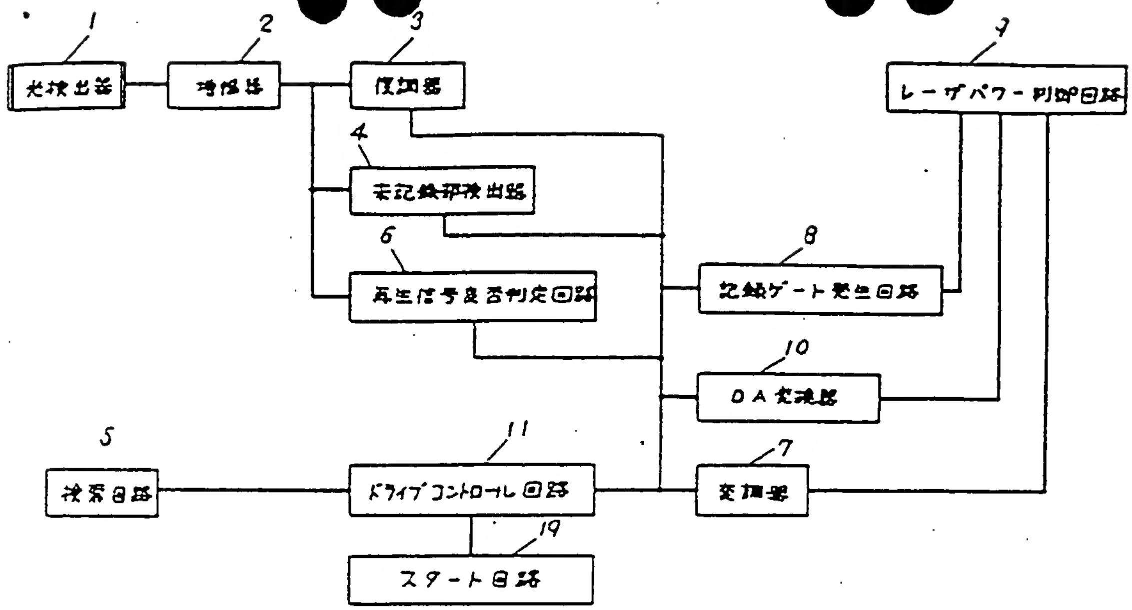

Figure 1
1: photodetector
2: amplifier
3: demodulator
4: unrecorded parts detector
5: search circuit
6: reproduction signal quality discriminating circuit
7: modulator
8: recording gate generating circuit
9: laser power control circuit
10: DA convertor
11: drive control circuit
19: start circuit

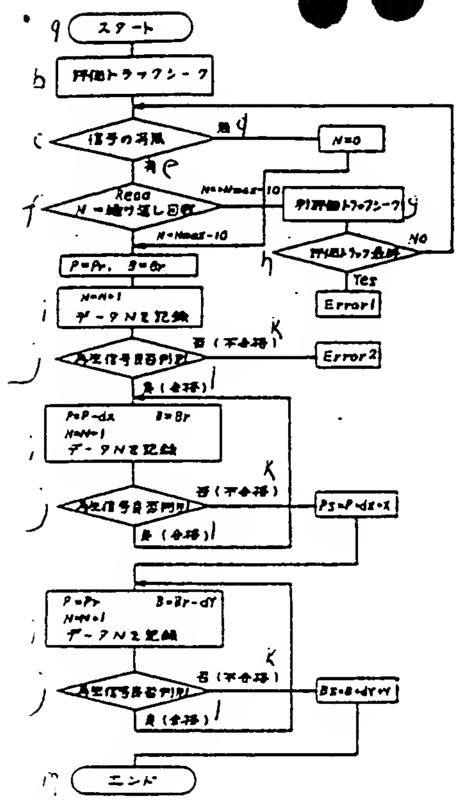

Figure 2
a: start
b: seek evaluation track
c: signal?
d: no
e: yes
f: read N = number repetitions
g: seek another evaluation track
h: final evaluation track?
i: record data N
j: discriminate reproduction signal quality
k: no good (does not pass)
l: good (passes)
m: end

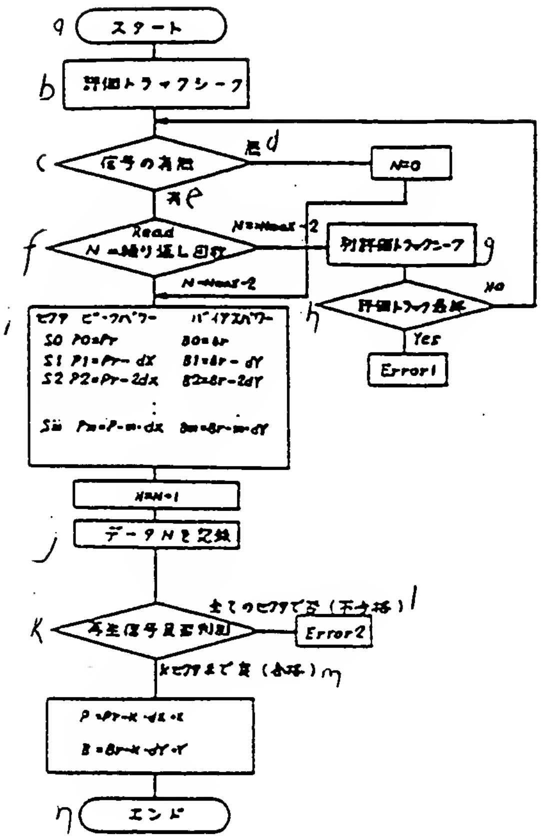

Figure 3
a: start
b: seek evaluation track
c: signal?
d: no
e: yes
f: read N = number repetitions
g: seek another evaluation track
h: final evaluation track?
i: sector / peak power / bias power
j: record data N
k: discriminate reproduction signal quality
l: no good (does not pass) in all sectors
m: good (passes) in sector k
n: end

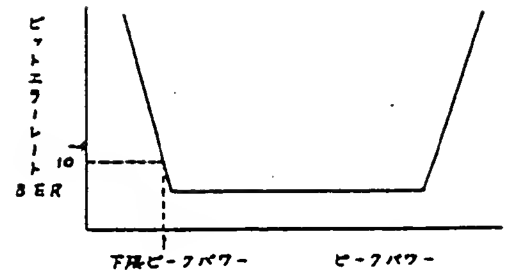

Figure 4
[X-axis:] Minimum Peak Power / Peak Power
[Y-axis:] Bit Error Rate (BER)

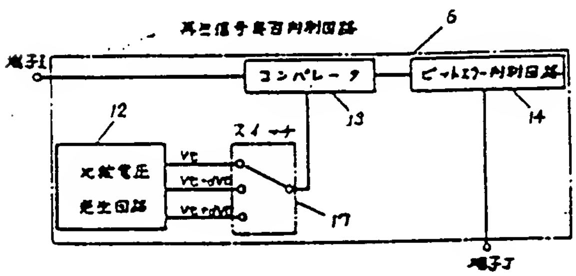

Figure 5
6: reproduction signal quality discriminating circuit
12: reference voltage generating circuit
13: comparator
14: bit error discriminating circuit
17: switch
[upper left:] terminal I
[lower right:] terminal J

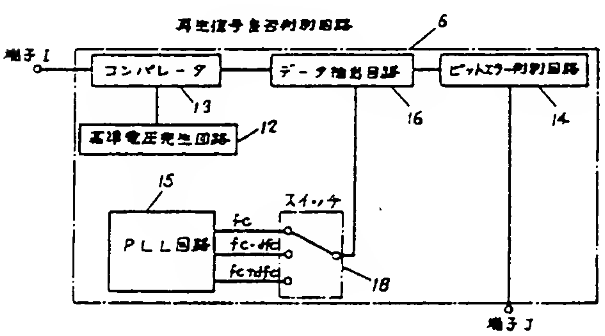

Figure 6
6: reproduction signal quality discriminating circuit
12: reference voltage generating circuit
13: comparator
14: bit error discriminating circuit
15: PLL circuit
16: data extracting circuit
18: switch
[upper left:] terminal I
[lower right:] terminal J

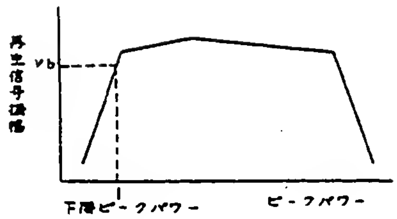

Figure 7
[X-axis:] Minimum Peak Power / Bias Power
[Y-axis:] Reproduction Signal Amplitude

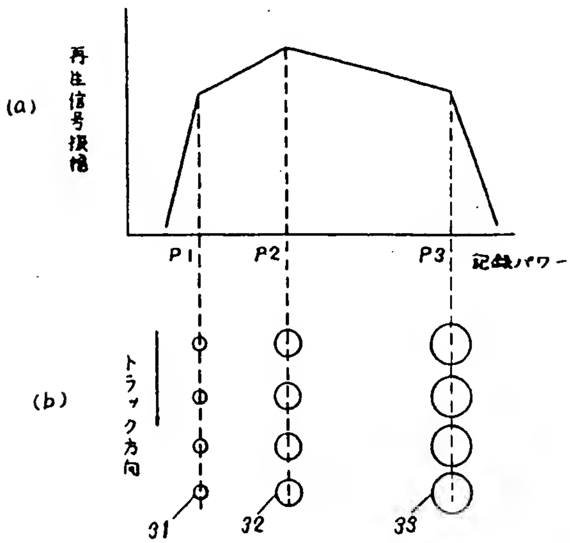

Figure 8
(a) [Y-axis:] Reproduction Signal Amplitude
[P1 to P3:] recording power
(b) track direction

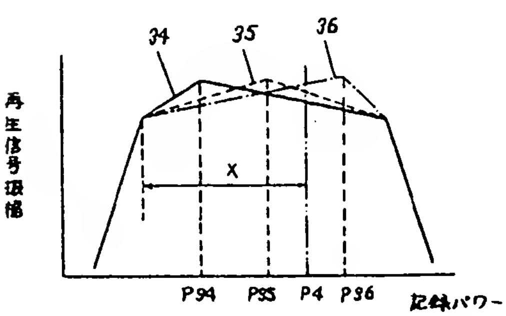

Figure 9
[Y-axis:] Reproduction Signal Amplitude
[P34 to P36:] recording power

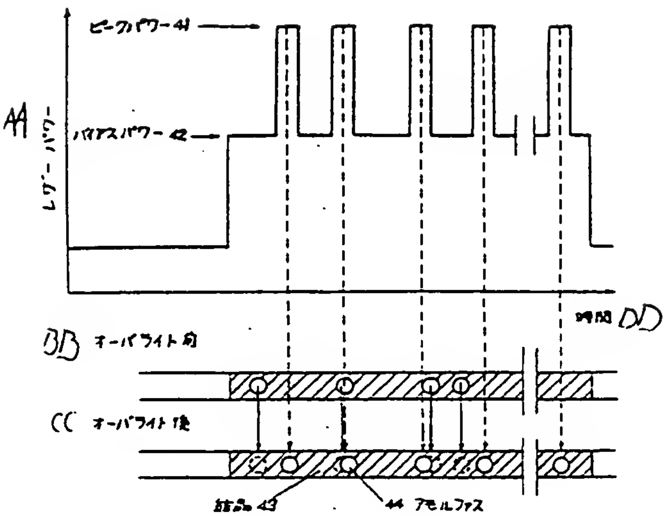

Figure 10
41: peak power
42: bias power
43: crystal
44: amorphous
AA: Laser Power
BB: before overwriting
CC: after overwriting
DD: Time